Managing the Megacity for Global Sustainability

The New York Metropolitan Region as an Urban Biosphere Reserve

CHRISTINE ALFSEN-NORODOM,[a] SUSAN E. BOEHME,[b] STEVEN CLEMANTS,[c] MELODY CORRY,[d] VALERIE IMBRUCE,[e] BENJAMIN D. LANE,[d] ROBERTA BALSTAD MILLER,[f] CHRISTINE PADOCH,[e] MARTA PANERO,[b] CHARLES M. PETERS,[e] CYNTHIA ROSENZWEIG,[g] WILLIAM SOLECKI,[h] AND DANIEL WALSH[a]

[a]*CUBES: Columbia University/UNESCO Joint Program on Biosphere and Society*

[b]*Harbor Project, New York Academy of Sciences, New York, New York*

[c]*Brooklyn Botanic Garden, Brooklyn, New York*

[d]*CUBES: Columbia University/UNESCO Joint Program on Biosphere and Society, New York, New York*

[e]*New York Botanical Garden, New York, New York*

[f]*CIESIN/Columbia University, New York, New York*

[g]*NASA–Goddard Institute for Space Studies, Columbia University, New York, New York*

[h]*Department of Geography, Hunter College of the City University of New York, New York, New York*

ABSTRACT: The UNESCO World Network of Biosphere Reserves (WNBR), while not originally conceived to include urban areas, was intended to include sites representing all significant ecosystems with the goal of support for sustainable development locally and globally. Drawing on the example of the New York Metropolitan Region (NYMR), which has a population of 21.4 million, it is argued here that the eventual inclusion of the largest of the world's cities in WNBR not only is within the logic of the biosphere reserve concept, but would also benefit the network and its goals. The ecological significance of the NYMR, its role as a driver for global environmental change, as well as the efforts under way in the city to improve urban environmental management and governance are all

Address for correspondence: Benjamin D. Lane, Field Coordinator, CUBES, Earth Institute at Columbia University, 2910 Broadway, Hogan Hall B-16, New York, NY 10027. Voice: 212-854-0268; fax: 212-854-6309.
ben2002@columbia.edu

Ann. N.Y. Acad. Sci. 1023: 125–141 (2004).
doi: 10.1196/annals.1319.005

examined. Potential added value to the WNBR of including megacities such as the NYMR is considered, in particular, regarding the sharing of best practices, lessons learned, and the strengthening of links between megacities and their global natural resource bases.

KEYWORDS: biosphere reserves; world network of biosphere reserves; urban ecosystems; industrial ecology; ecological footprint; urban agriculture; megacities; environmental governance

INTRODUCTION

Since its inception in the 1970s, the UNESCO biosphere reserve concept has developed into a powerful management and governance tool for sustainable development at widely diverse sites around the world. Although first conceived as a means for protecting pristine ecosystems, biosphere reserves have increasingly been established in areas where human activities play more obvious roles in ecosystem functioning. In recent years, the biosphere reserve model has been employed in periurban and urban areas; however, its potential for large cities remains untested.

Rosenzweig and Solecki (2001) first proposed that the New York Metropolitan Region (NYMR) could benefit from becoming a biosphere reserve, arguing that "application of the biosphere reserve strategy [would] enable resource decision makers to better understand the connections between biodiversity and urban societal demands," thereby allowing them to be "more responsive to potential environmental changes on longer time horizons, and flexible in the face of increased uncertainty," and that an NYMR Biosphere Reserve would "provide an excellent pathway for integration of new environmental management proposals, such as climate change adaptation strategies into stakeholders' decision-making practices."[1]

A major theme of the CUBES/UNESCO/UN-Habitat/New York Academy of Sciences conference *Urban Biosphere and Society: Partnership of Cities* was to examine how the biosphere reserve concept could be successfully applied to urban areas such as New York,[2] Seoul,[3] Rome,[4] Stockholm,[5] and Cape Town.[6]

We pose a complementary notion. Whereas others are concerned primarily with the value of the biosphere reserve concept to large cities, we argue that the application of the biosphere reserve concept to large cities is a potentially valuable contribution to global sustainability. In particular, we argue that the eventual inclusion of the largest of the world's cities in the UNESCO World Network of Biosphere Reserves (WNRB) not only is within the logic of the biosphere reserve concept, but would also actively benefit the network and its goals. To illustrate our arguments, we draw on the example of the NYMR,

one of the world's largest urban areas and one of its most radically transformed environments.

The World Network of Biosphere Reserves was established in 1975 by UNESCO's Man and the Biosphere Programme (MAB) to promote "a sustainable balance between the sometimes conflicting goals of conserving biological diversity, promoting economic development and maintaining associated cultural values."[7] A defining aspect of biosphere reserves is the emphasis on fulfillment of three distinct functions of sustainability, these being *conservation* ("of landscapes, ecosystems, species and genetic variation"), *development* ("economic and human development which is socioculturally and ecologically sustainable"), and *logistic* ("demonstration projects, environmental education and training, research and monitoring related to local, regional, national and global issues of conservation and sustainable development").[8] Following from these functions are the technical implementation procedures for biosphere reserves, including, notably, the zonation structure of core, buffer, and transition zones that was pioneered by the biosphere reserve concept. The sites selected for biosphere reserve status were by design highly diverse, with the goal of developing a "world representative network for research, monitoring, information exchange, and training."[9] Thus, while the WNBR originally was not conceived to include urban areas, it *was* intended to include sites representing all significant ecosystems with the goal of support for sustainable development locally and globally.

The NYMR is ecologically significant in its own right, as well as in terms of the global impact of consumption and production activities concentrated there. Indeed the NYMR and other megacities should be seen as drivers of global environmental change, for better or for worse. Sustainable management of highly complex and dynamic systems such as the NYMR, including strengthening of linkages with its global natural resource base, is therefore of fundamental importance to global sustainability as well as to the well-being of urban ecosystems.

Our focus is on "megacities," that is, cities with populations over 10 million. Global urbanization is occurring most rapidly in small to medium-sized cities, and it is in these middle cities that we may in the near future expect the most drastic environmental consequences of urbanization. By 2015 it is projected that there will be 61 very large cities, with populations over 5 million. Of these, 20 are already megacities.[10] These have enormous economic, social, and political influence and may be thought of as the world's leading cities. Moreover, megacities represent the extreme end of the continuum from "pristine" areas to built or completely "human generated." If it is reasonable and beneficial to include both ends of the continuum in the WNBR, then it should follow that the same will hold for other types of urban areas and urban/periurban/rural mixes. Thus, in arguing here for the value of including megacities such as the MYMR, we are by extension arguing the benefits of including the entire range of cities.

THE NEW YORK METROPOLITAN REGION AS AN URBAN ECOSYSTEM

Megacities are typically characterized by a history of progressive densification of population and supportive infrastructure, and buildup and succession of industrial land-uses, with development initially superimposed on a natural landscape and displacing existing habitats. This brings with it profound changes in the physical and biotic components of the environment from changes in the climate, soils, hydrology, and biodiversity. Increasing population and urbanization frequently are accompanied by air and water pollution, soil compaction, reduction in soil organisms and calcification of soils, increased loads of heavy metals and organics, and altered temperature and moisture regimes.

The process of urbanization frequently is seen primarily in terms of this superimposition, displacement, and destruction of habitats. However, the process is also one of ecological adaptation and resilience, as well as the development of new and dynamic anthropogenic habitats. Indeed, megacities may be seen as the most drastic examples of the interactions between people and nature. Because of their long history of human habitation and the density and diversity of settlement and land-use, megacities can serve as laboratories for studying such interactions, ranging from species and ecosystem resilience to the relationship between societal and biological diversity. Megacities would also seem to be particularly well suited for inclusion in a network of sites devoted to promoting healthy interactions of humans and biota within the urban environment.

The NYMR provides a dramatic illustration of these interactions. It is one of the most densely settled urban areas in the world, with a total population of some 21.5 million persons, of whom 8.0 million live in New York City.[11] Although the region covers only 33,670 square kilometers, it maintains great demographic diversity. New York has always been defined as a region of immigrants, and in the period from 1950 to 2000, international migration from new areas such as Latin America, Asia, and Africa has further diversified the population. Because of its large population, New York has pioneered in developing new urban infrastructure, including skyscrapers, subways and new forms of transit, and massive apartment complexes. These uses of land require supporting infrastructure for the water, energy, waste disposal, and other services needed by large, densely settled populations.

The prehistoric ecology of the region has been significantly modified. The NYMR is a water-dominated region with a diverse landscape. Large waterways and water bodies, among them the New York Harbor, Hudson River, East River and Long Island Sound, and Jamaica Bay cut deeply into the land area. The three physiographic regions are the coastal plain, the Piedmont, and the Appalachian highlands. Given its coastal location, much of the land area is at relatively low elevation. Human settlement has always played a part in

transforming the pre-European ecosystem of the New York Harbor, and successive waves of settlement have each had an impact on the region. Since 1950, suburban settlement has extended the human-dominated landscape to the farther reaches of eastern Long Island, northwestern New Jersey, and parts of Connecticut and New York State more distant from New York City.

From the early days of European settlement, land and open water in the areas surrounding the urban fringe were commonly utilized for disposal of refuse (solid wastes). This process accelerated in the 19th century with the exploitation of submarginal tidal and freshwater wetlands along the waterfront adjacent to the early urban core (southern Manhattan and northwest Brooklyn). These early landfills were commonly used to raise bulkheads and extend the reach of usable land. In conjunction with dredging, these straightened and heightened waterfront areas supported development of the city's port, providing access for shipping commerce and marine transportation.

During the early part of the 20th century, the population increased rapidly and denser settlement expanded outward from the urban core, northward into Bronx, eastward into Queens County and southeast into Brooklyn. The spread of land development was supported by expansion of urban infrastructure, such as the network of paved streets and systems for water supply, sewage control, stormwater conveyance, and solid waste disposal. New York City's five counties are all largely bounded by water, and most of this shoreline originally was occupied by highly productive marsh environments. Filling of these submarginal lands, which were deemed useless by city managers of the period, would provide the base for much of the municipal infrastructure that would support 20th century expansion of the city's population, including airports, highways, bridges, parks, and public beaches. Like wetlands on Manhattan's shoreline, which were largely filled by the end of the 19th century, the waterfront and inland wetlands in the other boroughs of the city were largely eradicated in the early and mid-20th century. This occurred largely through the disposal of refuse as fill material and was justified on a variety of grounds, including protection of public health (e.g., the elimination of breeding grounds for mosquitoes and rats). In addition to providing for municipal infrastructure, these new lands ultimately would expand the city's usable land area by 25% and would greatly increase the city's taxable land area. Although the total population in New York City proper peaked by 1940, redistribution of inhabitants would continue for the remainder of the century, leading to the consumption of almost all nonpark, open land in the city's four inner boroughs.

The dramatic effects of these transformations have not been limited to the topography of the region. New York City has experienced rainfall that has an average pH of 4.4 for the last 30 years; local soils contain levels of heavy metals such as lead, nickel, and copper, which are 5–10 times higher than those in rural areas; and daytime temperatures may be 6–8 degrees above those recorded outside the city. Add to this millions of pedestrians, hikers, shoppers,

and delivery people, who compact the soil, inadvertently trample seedlings, disperse seeds, and sometimes forget to dispose of trash properly, and the result is a host of new niches for plants and animals. In effect, the northern hardwood forest has been transformed into vacant lots, backyards, city parks, sidewalks, and urban gardens.

It therefore might come as a shock to visitors or even residents of New York City, but the city is in fact very green: 49,854 acres or 25.7% of the surface of New York City is parkland or open space.[12] It also contains a very diverse flora of 2,330 species. These species represent natives to the region as well as species brought to the city through its ports over the past 400 years.

The vegetation of the city can be classified into three types: residual native vegetation, cultivated areas, and restored vegetation growing where the natural vegetation has been disturbed by humans. The major open space is made up of residual native vegetation found either in parks or peripheral regions of the city. This native vegetation is extremely important for a variety of reasons: it provides ecological services to the city, habitat for native and migrating fauna, a reservoir of native species that can repopulate restored regions, and it creates areas of great enjoyment for the people of the city.

Many of the tree species native to the area have not adapted well to the changed environmental conditions and new habitats. Growth rates and plant vigor in the city have decreased, and several native taxa have become highly susceptible to pathogens and interspecific competition. The hemlocks are being attacked by wooly adelgids; flowering dogwoods and butternut hickory are plagued by canker; the beech trees have beech bark disease; the oaks have oak wilt; and a bacterium carried by leafhoppers is killing the white ash trees. Many of the oaks and hickories in city parks are unable to regenerate themselves because of the intense seed predation from resident squirrel populations.

Nonetheless, these areas still maintain extensive wildlife habitat and ecological function. The ecological function of the more densely settled part of the region is low. Yet the few remaining large-scale (i.e., greater than 500 hectares) habitat sites such as Jamaica Bay provide critical stopping points for migratory bird species.

Research at the Brooklyn Botanic Garden's New York Metropolitan Flora program has found that some native species appear to be more resilient to the effects of urbanization than other species. For instance, virtually all members of the Ericaceae (blueberry family) in the region are showing a decline over the past century. On the other hand, all native maples and most oaks are showing an increase over the same period. And while much of the native habitat has been lost over the past 400 years of settlement of the region, we still find federally threatened and endangered species within the city limits, such as the seabeach amaranth found on city beaches.

With the demise of the native flora, new niches were created for species that could tolerate the new conditions. Although many of these plants would

be designated as "exotic," "nonnative," "alien," or "invasive" in the current vernacular, these species have a demonstrated ability to grow and reproduce under acidic rainfall in droughty compacted soils with toxic levels of heavy metals. By some estimates, between 20% and 60% of the animals and plants in the Hudson River system are nonnatives that have systematically replaced many native populations.[13] In the process, nonnative species have filled important ecological niches left open by less resilient natives, thereby contributing to the robustness of the new urban ecosystems. These transformations have an added social dimension, because the variety of introduced species over the past four centuries have reflected the origins and preferences of the various waves of immigration to the city.

Concurrent with the transformation of original ecosystems and displacement of original habitats, the region has seen the development of a multitude of new habitats that are to a large extent anthropogenic. Filling of wetlands created a suite of "second-generation" (filled) land areas that have escaped subsequent redevelopment. Their resilience to development is related mainly to their landfill origin, which rendered them less desirable than other available properties. These filled and altered lands have since had sufficient time to accommodate new habitats, and repopulation with unique flora and fauna has been reported in some areas. This repopulation has been largely unmanaged and has occurred by natural means on properties that otherwise are considered to be vacant and nonfunctional lots. With the few remaining areas of undeveloped land, mostly contained in parks, these lands constitute much of the city's natural habitat. Less visible new habitats include cemeteries, gardens, backyards, balconies, green rooftops, road verges, railway sidings, and vacant lots, as well as subterranean and interior habitats. The variety and success of these habitats is the product of many factors, including planning decisions or lack thereof, public attitudes, the property market and institutional incentives affecting it, as well as the diversity of the people living in the city. Thus, while we may expect a great diversity of habitats in most large cities, the particular mosaic of habitats present is specific to the dynamics of that city's ecological and human history.

The practice of urban agriculture exemplifies many of the social and ecological processes described above, and it presents a context in which urban inhabitants interact directly within their local environment as well as distant, if not nostalgic environments of cultural, historic, or psychological significance through the preferential cultivation of plant species and varieties. In New York City, urban agriculture primarily exists in the form of community gardens. Within the agroecological context of the garden plot, the diverse social makeup of the city comes together with its abiotic and biotic environment. The services that urban agriculture provides to the city are many. They range from social, ecological, and political to economic importance.

Currently, cities across the world have varying dependencies on urban agriculture for food security and local economy. In New York, there was little

planning of urban agriculture within the confines of the city limits, most likely because the outlying or peripheral zones of the city are easily accessible and were highly productive agricultural zones. With few exceptions, as the city grew it pushed its agricultural areas further and further away, so that in 2003 the last working family farm within the city limits of Queens County was sold for 4.3 million dollars. The 20,000–square foot property could become 22 three-family homes. Urban agriculture does, however, continue to exist through backyard gardening and cultivation of abandoned lots.

Long a feature of the social, cultural, and ecological vitality of New York City, urban agriculture also has played an important role in the city's political agenda during times of financial crises. During the Great Depression, the city's welfare department along with a federal program sponsored "relief" gardens for the unemployed. The program was canceled in 1937 and lay dormant until World War II, when the city announced that all available public land could be cultivated as Victory Gardens. The post–World War II economic boom quenched the financial need for urban agriculture, and many gardens were abandoned, but with the 1970s came other needs that led to a resurgence in community gardening. The sort of urban agriculture that began in 1973 is now a vital part of urban life, but is of a different character than the agriculture of the past. While economic considerations still play an important role, it is now centered at the interface of social and ecological issues.

The founders of current urban agriculture in the NYMR see themselves as social and political activists. They took the initiative to cultivate and beautify abandoned lots with creativity, astute fundraising skills built on social justice, and political savvy to earn the recognition and support of the New York City government after their project was under way. These "Green Guerillas," as the organization is still called, incited community development through gardening around the City. The Parks Department established the Green Thumb program in 1978 which leases city land for a nominal fee to community gardens and turns gardeners from squatters to people with contractual rights to the land.

By nature, community gardens support ecosystem functions, such as carbon, water, and oxygen cycling, and biodiversity, such as soil microbes and invertebrates, insects, and birds as well as volunteer and cultivated plants species. But as managed agroecosystems, they reflect the cultural preferences and ethnic pride of their gardeners. As products of the interactions between diverse cultures and the built and natural environment, they exemplify the dynamism of urban environments.

The NYMR is anything but pristine, but neither is it simply a "concrete jungle." Although often viewed as a giant agglomeration of degraded natural ecosystems, the NYMR presents an example of a highly dynamic and complex ecological environment that provides an excellent laboratory for studying resilience to environmental change, options for ecosystem conservation and restoration, and the interactions between biological and societal diversity.

One of the primary purposes for establishing the World Network of Biosphere Reserves was to create a global network of representative ecosystems as "living laboratories" for research into ecosystem function, conservation and sustainable development.[9] In order that such a network may achieve its scientific potential, it should therefore cover the entire global range of ecosystems. While there may be ideological justifications for excluding a megacity such as the NYMR from consideration for biosphere reserve designation, the scientific value of such a study site is clear.

NEW YORK AS A DRIVER FOR GLOBAL ENVIRONMENTAL CHANGE

The efficiencies provided by urban density have demonstrated themselves to be a key ingredient of economic growth, ideally bringing with it increased wealth for urbanites and society as a whole, but with this growth comes increased consumption of natural resources. Indeed, urban areas require more resources than their regions can provide and must import food, building materials, and fuel from elsewhere. Because consumption levels tend to increase linearly with wealth, urban areas—particularly those in developed countries—place a disproportionate demand on resources and produce a disproportionate amount of waste and pollution. Wealthier cities also contribute disproportionately to global environmental problems such as emissions of greenhouse gases, creation of tropospheric ozone pollution, acid rain production, release of carcinogens and toxic materials, surface runoff contamination, erosion, and natural resource depletion, all of which affect local and global biodiversity.[14] While waste production, water, and land-use primarily have had regional impacts (although New York City sends much of its waste out of the state for disposal), food, energy, and other natural resource extraction, as well as certain pollutants such as CO_2, have global significance.

One way of comparing resource use and land management is by calculating an area's ecological footprint, or what can be otherwise designated its resource shed. The ecological footprint is the interactive relationship between an urban area and its hinterland (see Rees 1992[15]; Folke *et al*. 1997[16]; and the April 2001 special issue of *Ecological Economics* for more information about the concept and its application). This relationship often is defined as the measure of resources extracted and waste emitted for a given city or urban region. The ecological footprint also can be defined spatially as the area from which a city draws its resources and to which it delivers its wastes, or as the amount of productive land needed to sustain a city's population and its consumption levels.[17]

With a gross regional product of slightly less than one trillion dollars per year,[17] the NYMR's economy is roughly on a par with that of countries such

as Canada and Brazil.[18] Not surprisingly, its regional and global environmental impacts are enormous. The NYMR's annual energy demand is the equivalent of approximately one billion barrels of petroleum, half of the total U.S. production.[19] It relies on 5,000 km^2 of watershed and consumes 5,300 million liters of water daily.[1] The city produces some 14,000 tons of garbage[20] and 1.7 billion gallons of treated effluent daily.[21] It must import almost all of its food, and it has been estimated that it consumes approximately 800,000 hectares of wheat annually.[1] The city's wealth enables it to consume large quantities of ecologically inefficient meat products, as well as luxury goods such as coffee, tea, and tobacco, which has a corresponding impact on the warm climate ecosystems from which these goods are imported.

A less dramatic but illustrative example of the global impact of the NYMR's consumption patterns is presented by its enormous and ever-changing market for a large variety of plant species. Some of the diverse plant products consumed in the city are produced locally and regionally; much is imported from around the world. As a populous and ethnically diverse urban area, the city's demands in volume and variety of products affect the state of biological diversity both in surrounding rural areas as well as distant corners of the world. Much of the city's "ecological footprint" is formed by the breadth and weight of this consumer demand.

Demand in urban areas for ethnic or otherwise "exotic" produce is driven in part by immigration and in recent years is facilitated by free-trade agreements. A particularly significant trend is the "tropicalization" of consumer demand in northern, temperate cities such as New York. Tropical peoples move to temperate environments, bringing with them needs and desires from their tropical homes. This type of demand, coupled with the increasing political ease and economic advantage of growing export crops in tropical areas, has contributed to emerging types of export production for northern cities such as New York. Many complexities arise from the increasing demand for agricultural products from biologically rich, but often economically impoverished tropical areas of the world.

Immigrant communities in the NYMR have always contributed to the cultural diversity of the city, perhaps most visibly through the foods they offer urban inhabitants. The culinary diversity of the city is a great source of pride as well as income for the city, but its links to ecosystems abroad are obscure and not well understood. In the past century alone, the agriculture that supports city consumption has drastically changed, as has the city's cultural composition. The wave of immigration around the turn of the 20th century brought people from Ireland, Italy, and Eastern Europe, many of whom settled on regional farmland or had home gardens to cultivate the crops they were accustomed to eating. The availability of land, as well as the climatic adaptability of the "old immigrants" choice crops facilitated integration of new modes of consumption and production into metropolitan area. The second half of the 20th century saw the majority of its immigrants from Asia,

Latin America, and the Caribbean in place of Europeans. Currently Chinese, Indians, Mexicans, and Dominicans are the fastest-growing immigrant groups in the NYMR.

Paralleling the diversification of the city's demographic profile, there has been a substantial increase in the variety of fresh fruits and vegetables sold in city markets. As national and international trends have shown, sale of "exotic" produce is a lucrative and fast-growing segment of the fruit and vegetable trade. Over the past two decades in the City of New York, the number of species of tropical fruits and vegetables sold has increased by approximately 70%, and the number of Asian vegetables by 200%.[22] Analysis of the origin of the production areas shows shifts from countries that have long been providing tropical exports in the Caribbean to new production areas in South and Central America. Exports from Brazil, Argentina, Chile, and Colombia are replacing exports from Ecuador, Puerto Rico, and elsewhere in the West Indies. This shift is representative of the recent trend of diversification of exports from the Caribbean and Latin America. As the demand for a larger diversity of fresh fruit and vegetables as well as counter-seasonal produce has been growing in northern cities, there have been corresponding shifts in production. There has been a decrease in production of traditional exports from the tropics such as sugar, soy beans, and bananas to more profitable nontraditional agricultural exports.

Immigrants from tropical environments have demands that cannot be satisfied locally and create new connections to distant production landscapes. Although tropical fruits have been imprted to the city for at least a century, today the frequency, quantity, and variety of fresh tropical imports are cause for reevaluation of the processes of distribution and consumption of these items. The ease of transportation and communication, reduction of trade barriers, and the psychological importance of traditional food, including their role in maintaining non-American identities, has largely shaped these processes.

Clearly, the global reach of a megacity such as the NYMR gives it disproportionate influence over environmental and social conditions within and outside its boundaries, and the city's resource demands cannot be sustainable over the long term. The net effect of this influence is, however, largely a function of the consumption and production decision made possible by the city's wealth, rather than by its density in and of itself or merely the size of its population. Indeed, the efficiencies of urban density have direct environmental benefits as well. Recycling and composting usually are more cost-effective in higher-density cities, where there is a large surplus of used materials and sufficient industrial and residential need. Energy utilization tends to be more efficient in such cities because of the presence of high-rise buildings and public transportation systems. For example, in the NYMR, public transport use in 2003 was 9.06 million passengers per day,[23] saving millions of automobile miles and associated fuel consumption and CO_2 emissions. The same gains

in efficiency that make the accumulation of wealth and higher consumption possible also provide opportunities for social change and awareness building. This may partially explain why per capita expenditures on environmental protection also tend to be higher in urban areas, both in absolute terms and as a percentage of the gross national product.[24]

The NYMR is a driver for environmental change at the local, regional, and global levels. This can be change for the better or for the worse, depending on the consumption decisions made by New Yorkers as well as their degree of social, political, and economic engagement in support of global sustainability. An understanding of the relationships among all of the key factors involved in New York's ecological footprint will, however, require considerably further integrated research. The development and implementation of a research agenda to this end therefore is an important step toward a more sustainable NYMR. It also would be a vital policy-oriented scientific contribution to the World Network of Biosphere Reserves and its goals.

ENVIRONMENTAL MANAGEMENT FOR THE NEW YORK METROPOLITAN REGION

The concentration of population and wealth in a city such as New York makes good urban environmental management an imperative for the health of local, regional, and global ecosystems. This requires policies informed by scientific understanding, political commitment, public awareness, and a governance structure that allows for implementation.

Despite serious failings in all of these regards, the NYMR has some tradition of leadership in urban environmental conservation and management. It has stringent environmental laws that have resulted in improvements in the quality of its air and water since the 1960s, and it increased public parklands by 350,000 acres.[25] Significant research capacities in the city's academic institutions, botanical gardens, and conservation and planning organizations have been mobilized to increase understanding of urban ecosystems and urban sustainability, and far-sighted conservation, management, and planning initiatives have influenced its development.

One of the keys to the development of successful management has been the use of cross-disciplinary approaches integrating appropriate methodologies, policy instruments, and social coordination. This can help optimize interactions among socioeconomic, policy, and natural systems by pointing to opportunities to reduce negative impact on the environment and in some cases enhance quality of life. An example of this systems-view approach to natural and anthropogenic processes may be found in the new field of industrial ecology, which seeks to optimize the use of resources by dematerialization of the economy or material integration between production and postconsumption

processes. With its cradle-to-cradle approach, industrial ecology describes the flow of materials from nature through the economy and back to the environment, including pathways through different environmental media. Its analytical tools, such as material flow analysis and life cycle assessments, help find leverage points for intervention. The methodology of industrial ecology has been applied by the New York Academy of Sciences to examine the flows of specific contaminants into the New York/New Jersey Harbor and has been instrumental in identifying best management practices and opportunities for pollution prevention.

In any sociopolitical environment, the availability of good science alone will not ensure good policies. In the NYMR, the linkage between the two is often frustratingly weak, largely because of the dominance of an extremely large and diverse set of stakeholders implicated in any decision. In this situation, scientists become just another group of stakeholders.

Particular difficulties arise because of frequently overlapping and competing jurisdictions and mandates, resulting in the fragmentation of the city into smaller units. In the case of the NYMR, only 8 million of the total population of 21.5 million actually live in the City of New York. The rest live in hundreds of smaller municipalities spread across three states. With more than 2,000 separate jurisdictions within the NYMR, regional coordination is a daunting task.[25] Without coordinated policy and planning, many of the potential social, economic, and environmental advantages of urban density may go unrealized. It therefore is not surprising that some of the most influential and successful environmental management initiatives in the region have focused their efforts on developing regional solutions. An example of this type of initiative is the Port Authority of New York and New Jersey (PANY&NJ). PANY&NJ was established as an autonomous public-sector body to address the complicated transportation issues of a highly populated region situated in an estuary with a major port serving the region. The PANY&NJ defines its mission as "to identify and meet the critical transportation infrastructure needs of the bi-state region's businesses, residents, and visitors … move people and goods within the region, provide access to the rest of the nation and to the world, and strengthen the economic competitiveness of the New York–New Jersey Metropolitan Region."[26]

Organizations that unite the region around specific issues have been successful; however, this type of cooperation for a comprehensive management of this region has not been formally established. The kind of regional overview that would be necessary for integrated and collaborative environmental management of the NYMR not only will require cooperation and participation from a wide range of stakeholders from both states and federal entities, but, to be successful, these participants must have a strong sense of ownership of the process.

Many less formal programs and projects exist working on issues that cross state boundaries and thus include representatives from both states. The suc-

cess of these efforts can be limited, however, by the same boundary issues they are trying to overcome. It is very difficult to achieve consensus for example, when one entity is being asked to give up more than another for the good of the whole. Attempts to apply approaches using strategies of "decide, announce, defend" are unlikely to be successful when issues are affecting states, cities, and regions in very unique ways. A new paradigm in community outreach,[27] centering on communication follows a strategy of "inform, include, and decide."

The New York Academy of Sciences' Harbor Consortium[a] is an example of the application of this paradigm to a group with very diverse interests and backgrounds. This group has come together to take on issues of contamination in the NY/NJ Harbor, seeking to develop regional pollution prevention strategies. Its success stems from not only the inclusion of participants from all sides of the issues, but, more importantly, the transparency of the entire process in front of this group. This means that all of the participants see the logic and reasoning behind the scientific research being described and the next step of using that knowledge to make policy recommendations. Although many of the participants have points of view that are rooted in their own set of expertise, occupations, and interests, through the process they are better able to see how the person sitting next to them may have a different interest. The Consortium over a period of several years has coalesced into a group that sees itself as a true working group, and its members are willing to give their time and effort to identify pollution prevention strategies that are good for the region as a whole, even when those recommendations could have an impact on their own livelihoods.

Other important examples from the wide array of municipal, regional, national, and civil society initiatives improving the quality of life of citizens, protecting ecosystems, educating and raising awareness, and managing the global impact include Sustainable South Bronx, a civil society initiative focusing on environmental justice in some of the city's most underserved neighborhoods; the Regional Plan Association, a not-for-profit regional planning organization serving New York, New Jersey, and Connecticut; the Clean Ocean and Shore Trust (COAST), addressing coastal and ocean issues; the Brooklyn Botanic Garden/Rutgers University Center for Restoration Ecology; various Riverkeepers groups in the region; City and State environmental programs in the tristate area; the New York City Parks and Recreation Department; and the Gateway National Recreation Area, which protects some of the region's most sensitive wetlands. Although there remains ample room for in-

[a]The Harbor Consortium is composed of scientists, local, state, and federal government, industry and small businesses community and environmental groups, and labor and union representatives. The Consortium is the decision-making body for the project: Industrial Ecology, Pollution Prevention and the New York/New Jersey Harbor; and they participate in and oversee all aspects of the project from the initial research through the pollution prevention and management recommendations

creased cooperation, coordination, and commitment at all levels, these are long-standing and highly visible and successful initiatives that support conservation, development, and logistic functions espoused by the biosphere reserve concept.

THE ADDED VALUE OF MEGACITIES

The New York Metropolitan Region is ecologically significant. It is representative of increasingly important urban ecosystems and as such provides a valuable laboratory for the study of human impact, the resilience of native and ecosystems and species, the emergence of new ecosystems, and the dynamic social and ecological adaptive processes associated with all of these. The global ecological, economic, social, and political reach of a megacity such as the NYMR makes good urban environmental governance a key factor in the sustainability of ecosystems worldwide. Although environmental governance in the NYMR is flawed at best, there are significant public-sector and civil society processes under way to support sustainable development, research, education, policy coordination, and biodiversity conservation. It would be an exaggeration to suggest that the NYMR is in essence already a biosphere reserve, except for a formal zonation structure and designation as such. However, a NYMR Biosphere Reserve in principle could be achieved, and the necessary processes for a successful biosphere reserve are already well established in the city.

By including the NYMR and other cities in the WNBR, important networking opportunities present themselves. Lessons learned and other knowledge can be exchanged, and lost informational linkages between urban areas and their natural resource bases may be reestablished and strengthened through awareness building, education, exchange, and partnerships.

As one of the first megacities, New York City and its metropolitan region have been dealing with the ecological and social implications of extreme urbanization for longer than most cities, and there should be lessons available that would be of value to younger cities. For example, environmental conservation and management may be seen as a relatively low priority for cities in less-developed countries facing severe housing, health, and other poverty related issues. Yet many of the most successful environmental initiatives of the NYMR were developed in the context of interventions to alleviate poverty and improve public health.

Other lessons learned have been through the serious mistakes made over the years, such as the destruction of the region's wetlands, inappropriate infrastructure choices, jurisdictional and fiscal fragmentation, sprawl, and excessive pollution. All of these have imposed high costs on current and future generations, costs that may be avoided by younger cities.

One of the main problems posed by urbanization in general and megacities in particular is the increasing detachment of consumption activities from their natural resource bases; however, this is not limited to cities, but is in fact a feature of globalization in general. Awareness programs, partnership programs within the WNBR, and possible subnetworks of sites can help to strengthen and reestablish these linkages. This is particularly important as large cities become increasingly global in their makeup and their consumption. One could, for example, foresee a subnetwork within the WNBR that would link a conurbation such as the NYMR with biosphere reserves that are directly affected by its economy, consumption, and social and political influence. The establishment of such partnerships indeed could be a part of the establishment process for an urban biosphere reserve. This would provide an added value not only to the city's own environmental programs, but especially to the WNBR.

Given the stated goals of the UNESCO Man and Biosphere Programme (MAB) and the World Network of Biosphere Reserves, as well as the key functions that biosphere reserves are designed to serve, the inclusion of megacities in that network seems appropriate. Indeed, this could greatly benefit the long-term relevance of biosphere reserves. This will, however, depend on the full networking potential of the WNBR's being recognized and supported by the MAB. It will also depend on the MAB's revisiting the biosphere reserve concept, not simply to facilitate the inclusion of megacities and other urban areas, but also more generally, to thereby enable biosphere reserves to meet the needs of the situation in which the world finds itself today.

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